A Techno-economic Assessment of a Proposed Energy from Waste plant in Lagos State, Nigeria

David McIlveen-Wright[1], Sina Rezvani[1], Ye Huang[1], David Redpath[1], Rasheed Banire[2], Hossein Mirzaii[2] and Neil Hewitt[1]

1 School of the Built Environment, Centre for Sustainable Technologies, University of Ulster, Co Antrim BT37 0QB, N. Ireland, UK

2 Faculty of Engineering, Kingston University, Roehampton Vale, London, UK.

*[1]dr.mcilveen-wright@ulster.ac.uk; [2]S.Rezvani@ulster.ac.uk; [3]Y.Huang@ulster.ac.uk; [4]D.Redpath@ulster.ac.uk; [5]R.Banire@kingston.ac.uk; [6]H.Mirzaii@kingston.ac.uk; NJ.Hewitt@ulster.ac.uk

Abstract

Nigeria is rich in fossil fuel resources, but mainly for export. The local infrastructure for electricity generation is insufficient, as it is only available in urban areas, and suffers from frequent interruption. Only a small percentage of the population benefits from grid electricity, with the remainder using diesel generators, or has no access to electrical power.

In recent years, the population of Nigerian cities has rapidly expanded, outstripping the infrastructure accommodation, including the waste disposal sector. Recently, waste management plans have been put in place for Lagos, with improved facilities for waste collection, landfill gas recovery, recycling and composting included in the waste management strategy. However, there has been no inclusion of direct energy recovery from wastes prior to landfill. A facility providing electricity generation from MSW (municipal solid waste) combustion offers the possibility of reliable electricity generation, reduced GHG (greenhouse gas) emissions, reduced waste volumes to landfill and extended landfill site lifetime.

In this paper, the typical waste distribution for a landfill site in Lagos State was quantified, whose energy content was evaluated, and the potential of using this waste for electricity generation has been examined and assessed. A proportion of the waste was considered to be available for energy recovery–as part of the environmental and waste management options, so that recycling and composting would still have their role. The economic viability of a 50 MWe EfW (Energy from Waste) combustion facility was first assessed using the Eclipse process simulator to calculate the Breakeven Electricity Selling Price (BESP), where the standard landfill tipping fee was assumed to be given to the EfW plant as a processing charge. The EfW plant BESP was found to be very competitive with typical coal-fired power plants. The BESP for the 50MWe EfW plant (Base Case) was found to be 9.57 £/MWh, with a payback period of 15 years, when the current tipping fee of £50/tonne of waste was charged for disposal (gate fee) at the EfW plant. This was very favourably compared with the BESP for a typical 600 MW supercritical pulverized coal-fired power plant, which would be 35.7 £/MWh in the USA and the current electricity cost of 39.5 £/MWh in Nigeria, implying that such an EfW plant would positively contribute to both waste management and electricity reliability in the area. It would also be of environmental benefit as it would lead to a mitigation in emissions of around 0.24 million tonnes of CO_2 per annum.

The sensitivity of BESP to plant capital costs, load factor and tipping fees was also calculated and analysed.

Keywords

Municipal Solid Waste; Energy Recovery; Energy from Waste; Emissions Reduction.

Introduction

Energy Scenario in Nigeria

Oil is the major source of income for the country and accounts for over 95% of its foreign exchange earnings (CIA, 2011). Nigerian oil reserves are the tenth largest in the world and were estimated to be over 37 billion barrels (CIA, 2011 and EIA, 2012) in 2011.

Most electricity in Nigeria is generated at central power stations using fossil fuel or hydro [Fadare, 2010]. Successive governments have placed secure, reliable electricity generation as a main priority for both domestic and industrial growth, but all have failed to deliver. Since December 2005, the Power Holding Company of Nigeria (PHCN) has operated and maintained power-generating stations with a total installed capacity of about 3.96 GW (CPE, 2010). In 2008, about 21.1 TWh of electricity were generated (NETL, 2007), which implied around 4.4 GW power operating at 60%. In 2009, about 20.3 TWh (CIA, 2011)

were generated, making Nigeria the 70th largest generator in the world. Maximum capacity is around 5.6 GW, but only 3.6 GW is available regularly, due mainly to the age of the power plants and inadequate maintenance.

Grid supply is frequently intermittent too, so that the population has come to rely on, often very inefficient, petrol and diesel generators and Nigeria has been named the "Generator Republic". The estimated total private generation of electricity is about 2.4 GW, making Nigeria the largest purchaser of private electricity generating equipment in the world (Aboyade, 2004). It has been estimated that 60 million Nigerians own private power generating sets for electricity production, spending a staggering NGN1.56 trillion ($13.35bn) to fuel them annually (Sanusi, 2010).

At the time of writing the electricity price per kWh in Nigeria is 10 NGN (0.0395 GBP, or £39.5/MWh) (UNFCC, 2010) as proposed in the Tariff Development and Rates Approval-Approved Revenue Requirement (Ahmed, 2008).

Waste Management in Nigeria

Until 1977, waste management was almost unknown in Lagos, but being voted world's 'dirtiest' capital, when they hosted FESTAC, was a wake-up call (Alohan, 2011 and LAWMA, 2011). Since that time waste management plans have been put in place and recent refinements have included recycling (Kofoworola, 2007), landfill gas recovery (Aboyade, 2004) and composting (UNFCC, 2010), and it has been proposed that waste management in Nigeria could lead to wealth creation and poverty reduction (Ezeah, 2012). However, as yet there has been no attempt to employ energy recovery from waste (EfW) as a method for reducing waste tonnage, generating electricity and reducing emissions. In Valencia, Spain, some scenarios for solid waste management have been examined using life cycle analysis (LCA), and those scenarios with energy recovery included performed better (Bovea, 2006).

Energy from Waste Plants

Modern EfW plants in the USA generate 600 kWh electrical energy from each tonne of waste, thus avoiding mining ¼ tonne of high quality coal or importing one barrel of oil (Oyelola, 2008). It also reduces the effect of carbon dioxide and methane release from landfill sites, since even in well-regulated sanitary sites, up to 25% of these gases are released into the atmosphere (Oyelola, 2008).

This EfW plant could provide a reliable, stable electricity source as well as reducing the amount of waste going to landfill, lowering GHG (greenhouse gas) emissions and conserving fossil fuel resources.

The incineration of waste has the great advantage that although it does not completely eliminate waste from being deposited at landfill, it reduces its weight and volume. The reduction of MSW has been estimated to be approximately 75% by weight and 90% by volume (Rand, 2000).

Scope of this Paper

Lagos state produces approximately 255,600 tonnes of solid waste every month (0.63 kg/capita/day) which is primarily made up of household, business and commercial waste (collectively classified as municipal solid waste (MSW) (Ogwueleka, 2009). In general these wastes are disposed of by landfilling, with minimal efforts made for source separation (Chum, 2011).

Interest in the composting (UNFCC, 2010), landfill gas use (Aboyade, 2004) and the recycling sectors Kofoworola, 2007) have made some headway recently, but electricity generation from waste combustion has not yet been developed.

Waste arisings in the vicinity of Lagos were assessed in this paper. Waste tonnages and their constituent components were quantified and their potential energy contents were calculated, taking into account their calorific values and moisture (and inert material) contents. An Energy from Waste (EfW) plant was proposed at a scale which could operate at a high load factor, but would only use a proportion of the waste so that other aspects of a waste management plan, such as recycling or composting, could still be implemented. The economics of the proposed EfW plant, and the sensitivity of the Breakeven Electricity Selliing Price to plant capital costs, load factor and tipping fees, were then calculated and assessed.

Methodology

In order to estimate the energy content of the waste, the tonnage of 'as received' waste must be known, as well as its moisture content. From this, the amount of dry waste can be calculated, and knowing the energy content of each waste type, the energy content of the waste can be obtained.

TABLE 1: MONTHLY TONNAGE AND ENERGY CONTENT OF WASTE

	Commercial		Industrial		Domestic		Total Energy
	'ar' Tonnes	TJ	'ar' Tonnes	TJ	'ar' Tonnes	TJ	TJ
January	5,560	47.5	14,246	252.9	64,461	573.8	874.2
February	23,538	201.4	45,021	799.2	197,004	1,753.6	2,754.1
March	33,759	288.8	43,303	768.7	180,921	1,610.4	2,667.9
April	38,964	333.4	46,688	828.8	188,672	1,679.4	2,841.6
May	29,440	251.9	38,616	685.5	152,000	1,352.9	2,290.4
June	12,376	105.9	14,845	263.5	177,614	1,580.9	1,950.4
July	26,246	224.6	34,107	605.4	169,206	1,506.1	2,336.1
August	30,934	264.7	35,873	636.8	195,002	1,735.8	2,637.2
September	45,237	387.0	38,435	682.3	165,166	1,470.2	2,539.5
October	35,517	303.9	33,092	587.4	176,049	1,567.0	2,458.4
November	45,745	391.4	40,900	726.0	160,982	1,432.9	2,550.4
December	45,963	393.3	43,250	767.7	185,814	1,654.0	2,815.0
Total	**373,279**	**3,193.8**	**428,376**	**7,604.2**	**2,012,891**	**17,917.2**	**28,715.2**
Average		**266.1**		**633.7**		**1,493.1**	**2,393.0**

Economic Analysis Method

The ECLIPSE process simulation package (Williams, 1996) has been used for the techno-economic analysis of a wide range of power plants, such as advanced Integrated gasification Combined Cycle systems (Mondol et al., 2009) or biomass co-combustion systems (McIlveen-Wright et al., 2011). In this paper, it was used to make a preliminary calculation of the break-even electricity selling price (BESP) of the proposed 50 MWe EfW facility, using the assumptions in Table 3.

With regard to the economics, the capital costs of the typical EfW plant modelled here is in the public domain, which means the specific investment (SI) can be easily calculated. Following the plant cost estimation, the breakeven electricity selling price (BESP) was determined based on the net present value (NPV). A number of sensitivity analyses were carried out to assess the effect of variation in such factors as discounted cash flow rate (DCF), gate fee. load factors, operational and maintenance costs (O&M) and capital investments.

Estimation of Energy Content of Waste Arisings in Lagos State

Using the 'ar' (as received) monthly tonnage of waste in each of the commercial, industrial and domestic sectors (CIA, 2011), and knowing the distribution of types of waste (Otegbulu, 2011), their dry, ash-free calorific values (Porteous, 2005) and moisture contents, within each sector, then the energy content can be derived, as shown in Table 1.

Sizing the Energy from Waste (EfW) Plant

The energy data in table 1 were averaged over each month to get the power, in Megawatts, contained in the wastes. For a fairly large modern EfW facility, similar to those constructed in smaller and medium sized cities in China using fluidised bed technology (Zhang, 2009), the electrical efficiency is assumed to be 28%. The monthly average power output was calculated, as shown in table 2. The waste collected was fairly constant over the year, except when the collection wais stopped in December, and an EfW plant, which took in all of Lagos's waste, could operate with a very consistently high load factor, ensuring high efficiency, as shown in table 2.

The proposed EfW plant would process 500,000 tonnes of waste per annum and the net electricity generated would be approximately 46 MWe.

This would meet a definite need, since the principal landfill site, Olusosun, increased its processed tonnage from 1,080,000 in 2007 to 1,425,000 tonnes in 2008 and to 1,974,000 tonnes in 2009 (Oresanya, 2010) under its

recent waste management upgrade. While new recycling and composting facilities have been put in place, there would still be a significant increase in landfill space usage.

Clearly, the proposed EfW plant could handle more than 25% of the non-recycled or non-composted waste, thus extending the lifetime of the available space by more than 30%.

TABLE 2: ESTIMATION OF APPROPRIATE PLANT SIZE FROM ENERGY CONTENT OF WASTE

	Total Energy	Thermal	Electrical Power	Load Factor
	TJ	MW	MW	
January	874.2	326.4	91.4	0.33
February	2,754.1	1138.5	318.8	1.14
March	2,667.9	996.1	278.9	1.00
April	2,841.6	1096.3	307.0	1.10
May	2,290.4	855.1	239.4	0.86
June	1,950.4	752.5	210.7	0.75
July	2,336.1	872.2	244.2	0.87
August	2,637.2	984.6	275.7	0.98
September	2,539.5	979.7	274.3	0.98
October	2,458.4	948.4	265.6	0.95
November	2,550.4	983.9	275.5	0.98
December	2,815.0	1051.0	294.3	1.05
Total	28,715.2			
Average	2,393.0			0.92

Emissions Reduction and Reduction in Fossil Fuel Use

The methodology in the IPCC's guidelines for national greenhouse gases inventories (Daskalopolous, 1997) as described by Tsai (2009), was used to estimate the GHG emissions reduction and the energy savings through using MSW instead of fossil fuels.

CO_2 Mitigation

The use of an EfW plant was ranked second only to a EfW plant with heat recovery with regard to GHG mitigation, as shown in Table 3 (Oresanya, 2010). In Europe, such technologies are in widespread use with 67 EfW CHP plants reported in municipal heating schemes in 2005 (Porteous, 2005).

Assuming the EfW plant has a net output of 46 MWe and a capacity factor of 92%, then it will generate around 370.7 GWh of electrical energy per year. If this electricity replaced that generated by a coal-fired power plant, or small, inefficient private diesel-fired generator, which emitted around 0.65 kg CO_2 per kWh of electricity generated, then the use of the MSW EfW plant would result in a mitigation of around 0.24 million tonnes of CO_2 per annum. Only 'displaced emissions' from electricity generation have been considered here, but further emissions should also be taken into account, such as the reduction in methane emissions from landfill due to lower amounts of putrescibles arriving there. Emissions were also saved by using recycled instead of virgin materials in product manufacture (Papageorgiou, 2009).

TABLE 3: RANKING OF WASTE MANAGEMENT ACTIVITIES IN TERMS OF GHG MITIGATION

Scenario	Emissions Offset kg CO_2/tonne waste	Ranking
EfW	12	2
EfW (CHP)	-216	1
MBT & landfill	104	3
MBT, RDF and Landfill	224	5
MBT with AD	210	4
Landfill with gas capture	502	6

Abbreviations: CHP: Combined Heat and Power;

MBT: Mechanical Biological Treatment;

RDF: Refuse Derived Fuel;

AD: Anaerobic Digestion

[Note: all of the combustible waste, except for the plastic fraction, is biogenic and not fossil in Nigeria.]

Economic Analysis Results

The ECLIPSE process simulation package has been used for the techno-economic analysis of a wide range of power plants, such as advanced Integrated gasification Combined Cycle systems or biomass co-combustion systems. In this paper, it was used to make a preliminary calculation of the break-even electricity selling price (BESP) of the 50 MWe EfW facility, using the assumptions in Table 4.

Economic Simulation Data

The tipping fee was assumed to be £50/tonne of waste, which was income for the EfW plant for the waste processed there. The same amount was also assumed to be charged for the ash disposed of to landfill from the EfW to landfill – 11% of the waste is assumed to be ash, and 70% of this ash was landfilled, with the remainder being recovered metal. [This is perhaps

unnecessary, since the ash can often be used by the landfill operator as a cover material for the landfill or as a low-grade aggregate in construction (Tsai, 2010). The sale of recovered metals has not been taken into account, but could be a valuable additional income stream.

TABLE 4: ECLIPSE COST DATA OVERVIEW FOR 50 MWE (46 MWE NET) EFW PLANT

EfW Plant Output	MWe	50 (46 net)
Total Process CC (EPC)	£ (2011)	110,000
Working Capital	EPC, %	2.0
Capital Fees	EPC, %	0.4
Contingency	EPC, %	10.0
Commissioning Costs	EPC, %	1.0
Total CC (inc. commissioning costs, working capital and fees)	£	113,740
Total CC (inc. contingency)	£	124,740
Specific Investment	£ /kWe	2,472.6
Annual Insurance Costs	%	1.0
Annual Operating Costs inc. labour costs	%	2.0
Discounted Cash Flow Rate	%	9.0
Annual Maintenance Costs inc. labour and supplies	%	2.5
Tipping Fee	£/tonne	50
Ash Disposal Costs	£/tonne	50

With these assumptions, which will be termed the Base Case, the BESP was found to be 9.57 £/MWh with a payback period of 15 years (as shown in Figure 1, where the gate fee is £50/tonne).

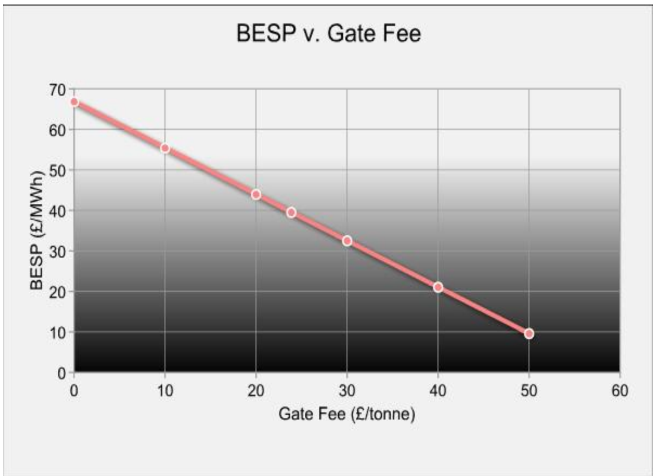

FIG. 1: BESP VERSUS GATE FEE FOR BASE CASE

Economic Assessment : Sensitivity Analysis

For the same Gate Fee and Tipping Fee for Ash of £50/tonne, the variation of Specific Investment of +25%, +50% and +100% from the Base Case and their effect on BESP are shown in Figure 2.

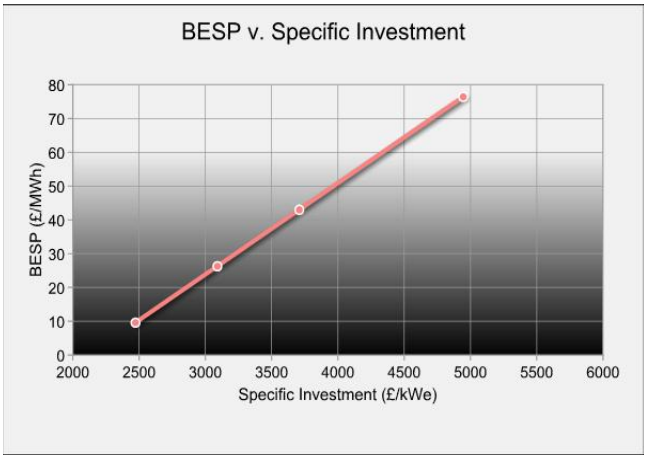

FIG. 2: CAPITAL COST VARIATION

In Figure 3, the variation of BESP with Gate Fee (and Tipping Fee) is shown for the same range of increase in capital costs (+25%, +50% and +100%) with the Base Case.

It can be seen that if the capital costs are actually 50% higher than the Base Case, then it would not be possible to generate electricity at the current market price of 39.5 £/MWh in Nigeria. In fact, to achieve this electricity price (39.5 £/MWh), and for a Tipping Fee of £50/tonne of waste (for the ash), then the Gate Fee would have to be 25.88, 39.35, 52.87, and 79.75 £/tonne for the Base Case, +25%, +50% and +100% increased capital cost cases respectively.

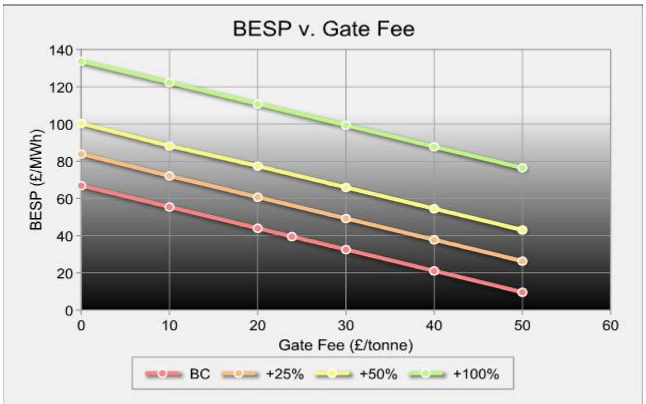

FIG. 3: BESP VERSUS GATE FEE FOR INCREASING CAPITAL COSTS

The Load factor (LF) can also have a significant impact on the BESP. It has been assumed that the LF would be relatively low in the first three years of operation and then the plant would operate at a fixed LF value. In

the Base Case, this was taken as 92% (corresponding to 11 months continuous operation). However, should it not be able to operate at this LF, the BESP will be adversely affected.

Figure 4 shows the impact of Load Factor variation on BESP for the Base Case.

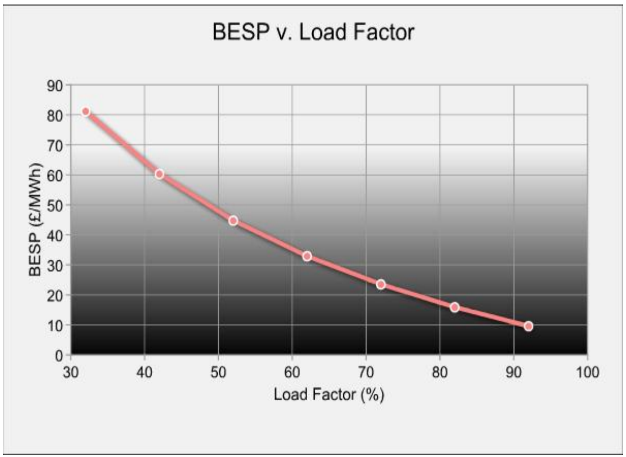

FIG. 4: EFFECT OF LOAD FACTOR

Conclusions

A method has been shown for assessing the MSW in Lagos for its potential in generating electricity. The type of waste and its quantity was found to be suitable to provide thermal energy which could sustainably generate electricity from an EfW plant without hindering other aspects of waste management in Lagos. The economics of this plant was found to be favourable in comparison with modern coal-fired power plants, for the capital costs assumed, and much better than the widespread use of small-scale generators in terms of economics and environmental impact. It would also result in an emissions reduction of around 0.24 million tonnes of CO_2 per annum. An EfW plant could supply electricity reliably and economically and form an important part of an environmental and waste management plant for this location.

The BESP for the 50 MWe EfW plant (Base Case) was found to be 9.57 £/MWh, with a payback period of 15 years, when the current tipping fee of £50/tonne of waste was charged for disposal (gate fee) at the EfW plant. This compared well with the BESP for a typical 600 MW supercritical pulverized coal-fired power plant, which would be 35.7 £/MWh in the USA [34] and the current electricity cost of 39.5 £/MWh in Nigeria. If the electricity from the EfW plant were sold at this price, then a Gate Fee and Tipping Fee (Ash Disposal Cost) of only £23.87/tonne would be necessary to break even. If the Tipping Fee remained at £50/tonne, then the Gate Fee would have to rise to £25.88/tonne to generate electricity at the market price. This would then be an attractive method of waste disposal, since it is half the cost of landfilling, reduces emissions, increases landfill lifetimes and provides a reliable, non-intermittent, indigenous means of electricity generation.

A decrease in Load Factor can have a significant impact on the BESP. However, in this case, the Load Factor could drop as low as 55% and the EfW plant would still be economically viable. This is unlikely to happen as the waste supply is fairly constant throughout the year and the plant has been sized to only rely on about 50% of the 2007 waste at Olusosun landfill site.

In Fig. 3 which shows the variation of BESP with Gate Fee for capital cost increases, it can be seen that if the capital costs are actually 50% higher than the Base Case, then it would not be possible to generate electricity at the current market price of 39.5 £/MWh in Nigeria. In fact, to achieve this electricity price (39.5 £/MWh), and for a Tipping Fee of ₤50/tonne of waste (for the ash), then the Gate Fee would have to be 25.88, 39.35, 52.87, and 79.75 £/tonne for the Base Case, +25%, +50% and +100% increased capital cost cases respectively. Therefore, the plant would still be viable when the capital costs even increased by as much as 25% above the base case.

REFERENCES

Aboyade, A., The Potential for Climate Change Mitigation in the Nigerian Solid Waste Disposal Sector: A Case Study from Lagos, in Environmental Strategy Department2004, Lund University. p. 47.

Ahmed, A.S., Investment Implication for the Projected Electricity Demand and Supply, in Energy Commission of Nigeria (ECN) & Nigerian Electricity Commission (NERC)Joint "National Workshop on State Government Participations in Power Sector: Matching Supply with Demand"2008: Sheraton Hotel & Towers, Abuja, Nigeria. Pp. 28.

Alohan, J. Nigeria: Electricity Regulatory Commission Explains Rise in Costs. 2011; Available from: http://allafrica.com/stories/201107010969.html.

Bovea, M.D. and J.C. Powell, Alternative scenarios to meet the demands of sustainable waste management. Journal of Environmental Management, 2006. 79(2): p. 115-132.

Chum, H., A. Faaij, J. Moreira, G. Berndes, P. Dhamija, H.

Dong, B. Gabrielle, A. Goss Eng, and M.M. W. Lucht, O. Masera Cerutti, T. McIntyre, T. Minowa, K. Pingoud,, Bioenergy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, R.P.M. O. Edenhofer, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, and P.E. T. Zwickel, G. Hansen, S. Schlömer, C. von Stechow, Editors. 2011: Cambridge, United Kingdom and New York, NY, USA.

CIA. The World Factbook, Africa, Nigeria. 2011 [cited 2011 07 Nov]; Available from: https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html.

CPE, Landfill Recovery and Use in Nigeria (Pre-feasibility studies of using LFGE) 2010, EPA: Washington. p. 57.

Daskalopoulos, E., O. Badr, and S.D. Probert, Economic and Environmental Evaluations of Waste Treatment and Disposal Technologies for Municipal Solid Waste. Applied Energy, 1997. 58(4): p. 209-255.

EIA. International Energy Statistics for Nigeria. 2012 [cited 2012 5th January]; Available from: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=57&aid=6.

Ezeah, C. and C.L. Roberts, Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Nigeria. Journal of Environmental Management. 2012, 103(): p. 9-14.

Fadare, D.A., The application of artificial neural networks to mapping of wind speed profile for energy application in Nigeria. Applied Energy, 2010. 87(3): p. 934-942.

Kofoworola, O.F., Recovery and recycling practices in municipal solid waste management in Lagos, Nigeria. Waste Management, 2007. 27(9): p. 1139-1143.

LAWMA. LAWMA - Who we are. 2011; Available from: http://www.lawma.gov.ng/insidelawma_whoweare.html.

McIlveen-Wright, D.R., et al., A Techno-economic assessment of the reduction of carbon dioxide emissions through the use of biomass co-combustion. Fuel, 2011. **90**(1): p. 11-18.

Mondol, J.D., et al., Techno-economic evaluation of advanced IGCC lignite coal fuelled power plants with CO2 capture. Fuel, 2009. 88(12): p. 2495-2506.

NETL, Cost and performance baseline for fossil energy plants, N.E.T. Laboratory, Editor 2007.

Oresanya, O. Progress and Challenges of Waste Management in Lagos, Nigeria. 2010 [cited 2011 18 October]; Presentation - Paper presented at the Faculty of Science, Obafemi Awolowo University Ile - Ife]. Available from: http://www.lawma.gov.ng/presentation/OAU%20Presentation.pdf

Ogwueleka, T.C., Municipal solid waste characteristics and management in Nigeria. Iran. J. Environ. Health. Sci. Eng., 2009. 6(4): p. 173-180.

Otegbulu A.C, J.U.O., Y.O. Afe, , The Built Environment Perspective of Climate Change- A Focus on Household Activities in Lagos Metropolis. Journal of Sustainable Development, 2011. 4(5): p. 174-188.

Oyelola, O.T., Babatunde, A. I, Characterization of domestic and market solid wastes at source in Lagos metropolis, Lagos, Nigeria. African Journal of Environmental Science and Technology, 2008. 3(12): p. 430-437.

Papageorgiou, A., J.R. Barton, and A. Karagiannidis, Assessment of the greenhouse effect impact of technologies used for energy recovery from municipal waste: A case for England. Journal of Environmental Management, 2009. 90(10): p. 2999-3012.

Porteous, A., Why energy from waste incineration is an essential component of environmentally responsible waste management. Waste Management, 2005. 25(4): p. 451-459.

Rand T., H.J.a.M., U.,, Municipal Solid Wate Incineration Technical Paper 462, 2000, World Bank. p. 118.

Sanusi, M.S.L., Funding of power projects: the role of the central bank of Nigeria (CBN) in Gas To Power: Prospects and Challenges 2010: Lagos.

UNFCCC, Municipal Solid Waste (MSW) Composting Project in Ikorodu, Lagos State 2010.

Williams, B.C. and J.T. McMullan, Techno-economic analysis of fuel conversion and power generation systems - the development of a portable chemical process simulator with capital cost and economic performance analysis capabilities International Journal of Energy Research, 1996. 20: p. 125-142.

Zhang, D.Q., S.K. Tan, and R.M. Gersberg, Municipal solid waste management in China: Status, problems and challenges. Journal of Environmental Management, 2009. 91(8): p. 1623-1633.